B777 Alerting Issues – Air data system failure

1. Initiating Condition: Blocked pitot source (captain's or left source)

Type	Alert or cue	Threshold for alert or cue to be presented	Confusion regarding alert or cue	Other issues with regard to alert or cue	When alert is inhibited/suppressed or when cue is masked	How alert or cue is terminated
Visual Alerts	None					
Aural Alerts	None					
Tactile Alerts	None					
Visual Cues	None					
Aural Cues	None					
Tactile/Somatic Cues	None					

Expected Pilot Response(s)

- None required - the failed or inconsistent source is automatically deselected and the air data inertial reference unit (ADIRU) continues with the remaining two consistent sources, providing the same airspeed value to both the Captain's and First Officer's PFDs. There are no failure annunciations or indications, so the pilots are not even aware of the change.

B777 Alerting Issues – Air data system failure

2. Initiating Condition: Blocked pitot sources (all sources blocked, first partially and inconsistently, then completely), with ram air pressure trapped in at least one pitot system during climb (e.g., blocked pitot drain)--Cont

Type	Alert or cue	Threshold for alert or cue to be presented	Confusion regarding alert or cue	Other issues with regard to alert or cue	When alert is inhibited/ suppressed or when cue is masked	How alert or cue is terminated
Visual Alerts	"NAV AIR DATA SYS" displayed in amber on EICAS	Air data received by both ADIRU and SAARU are inconsistent during period of partial blockage of all three inputs (neither can vote out a single bad input), and subsequently invalid during period of complete input blockage		Pilots may not immediately recall that the NAV AIR DATA SYS condition implies that their airspeed displays may be inconsistent/require resolution of correct vs. incorrect information; by the time they obtain this information from the relevant NNP, control of the aircraft may have been compromised		
	OVERSPEED warning displayed in red on EICAS (1) pressure is trapped in a pitot system by blockage and ambient pressure decreases; or (2) pilot follows a different airspeed display that is reading an incorrectly low value, into a true overspeed.	Indicated airspeed exceeds Vmo/Mmo, because either (1) pressure is trapped in a pitot system by blockage and ambient pressure decreases in the climb; or (2) pilot follows a different airspeed display that is reading an incorrectly low	It may not immediately be evident to the pilots whether this is a true or false warning, especially in the presence of inconsistent airspeed displays	Pilots responding to a false overspeed warning may enter or exacerbate a loss of control		

B777 Alerting Issues – Air data system failure

2. Initiating Condition: Blocked pitot sources (all sources blocked, first partially and inconsistently, then completely), with ram air pressure trapped in at least one pitot system during climb (e.g., blocked pitot drain)--Cont

Type	Alert or cue	Threshold for alert or cue to be presented	Confusion regarding alert or cue	Other issues with regard to alert or cue	When alert is inhibited/ suppressed or when cue is masked	How alert or cue is terminated
		value into a true overspeed.				

B777 Alerting Issues – Air data system failure

2. Initiating Condition: Blocked pitot sources (all sources blocked, first partially and inconsistently, then completely), with ram air pressure trapped in at least one pitot system during climb (e.g., blocked pitot drain) – Cont.

Type	Alert or cue	Threshold for alert or cue to be presented	Confusion regarding alert or cue	Other issues with regard to alert or cue	When alert is inhibited/ suppressed or when cue is masked	How alert or cue is terminated
Visual Alerts	Master warning lights in red on forward panel	Associated with EICAS OVERSPEED, because either (1) pressure is trapped in a pitot system by blockage and ambient pressure decreases in the climb; or (2) pilot follows a different airspeed display that is reading an incorrectly low value into a true overspeed.	It may not immediately be evident to the pilots whether this is a true or false warning, especially in the presence of inconsistent airspeed displays	Pilots responding to a false overspeed warning may enter or exacerbate a loss of control		
	Indicated airspeed numerical box turns amber	Indicated airspeed below Min Maneuvering Speed (signifying 1.3g maneuver margin to stall); AOA-compensated airspeed, not g-compensated				Increased airspeed
	AUTOPILOT DISC warning displayed in red on EICAS	Autopilot disengagement due to flight control mode degrading to secondary mode when indicated airspeed decreases to below 50 knots.	This alert is secondary to the air data system failures, and it may add to the workload and confusion of the situation.	Reversion to hand flying causes workload spike and is distracting.		
	Master warning lights in red on forward panel	Associated with AUTOPILOT DISC EICAS	This alert is secondary to the air data system failures, and it may add to the workload and confusion of the situation.			
	AUTO SPEEDBRAKE advisory displayed in amber on EICAS	Auto speedbrake system failure due to flight control mode degrading to secondary mode when indicated airspeed decreases to below	This alert is secondary to the air data system failures	NAV AIR DATA SYS procedure advises not to perform this procedure despite its being displayed on		

B777 Alerting Issues – Air data system failure

2. Initiating Condition: Blocked pitot sources (all sources blocked, first partially and inconsistently, then completely), with ram air pressure trapped in at least one pitot system during climb (e.g., blocked pitot drain) – Cont.

Type	Alert or cue	Threshold for alert or cue to be presented	Confusion regarding alert or cue	Other issues with regard to alert or cue	When alert is inhibited/ suppressed or when cue is masked	How alert or cue is terminated
		50 knots.		EICAS		
	FLIGHT CONTROL MODE caution displayed in amber on EICAS	Flight control mode degrades to secondary mode when indicated airspeed decreases to below 50 knots.	This alert is secondary to the air data system failures, and it may add to the workload and confusion of the situation.	NAV AIR DATA SYS procedure advises not to perform this procedure despite its being displayed on EICAS		
Visual Alerts	THRUST ASYM COMP advisory displayed in amber on EICAS	Thrust asymmetry computer failure due to flight control mode degrading to secondary mode when indicated airspeed decreases to below 50 knots.	This alert is secondary to the air data system failures, and it may add to the workload and confusion of the situation.	NAV AIR DATA SYS procedure advises not to perform this procedure despite its being displayed on EICAS		
Aural Alerts	Autopilot disengagement siren	Autopilot disengagement due to flight control mode degrading to secondary mode when indicated airspeed decreases to below 50 knots.	This alert is secondary to the air data system failures, and it may add to the workload and confusion of the situation.	Reversion to hand flying causes workload spike and is distracting.		
	Caution beeper	Associated with FLIGHT CONTROL MODE EICAS	This alert is secondary to the air data system failures, and it may add to the workload and confusion of the situation.			

B777 Alerting Issues – Air data system failure

2. Initiating Condition: Blocked pitot sources (all sources blocked, first partially and inconsistently, then completely), with ram air pressure trapped in at least one pitot system during climb (e.g., blocked pitot drain) – Cont.

Type	Alert or cue	Threshold for alert or cue to be presented	Confusion regarding alert or cue	Other issues with regard to alert or cue	When alert is inhibited/ suppressed or when cue is masked	How alert or cue is terminated
	Overspeed siren	Associated with EICAS OVERSPEED, because either (1) pressure is trapped in a pitot system by blockage and ambient pressure decreases in the climb; or (2) pilot follows a different airspeed display that is reading an incorrectly low value into a true overspeed.	It may not immediately be evident to the pilots whether this is a true or false warning, especially in the presence of inconsistent airspeed displays	Pilots responding to a false overspeed warning may enter or exacerbate a loss of control		

B777 Alerting Issues – Air data system failure

2. Initiating Condition: Blocked pitot sources (all sources blocked, first partially and inconsistently, then completely), with ram air pressure trapped in at least one pitot system during climb (e.g., blocked pitot drain) – Cont.

Type	Alert or cue	Threshold for alert or cue to be presented	Confusion regarding alert or cue	Other issues with regard to alert or cue	When alert is inhibited/suppressed or when cue is masked	How alert or cue is terminated
Aural Alerts	Stick shaker (sound of)	AOA	Stall warning may be valid if aircraft enters stall condition during loss of control while following incorrect airspeed references, but may not be considered to be valid by the pilots because of simultaneously displayed conflicting (high) airspeed and overspeed warnings (due to pitot system(s) in which the ram air pressure is trapped). Resolution of the discrepancy requires effortful reference to standby airspeed display and/or to pitch/power displays; Pilots may follow incorrect airspeed guidance into an undesired aircraft state or loss of control, because the airspeed display may appear valid and the process of identifying the discrepant display(s) may require substantial time			
Tactile Alerts	Stick shaker	AOA	Stall warning may be valid if aircraft enters stall condition during loss of control while following incorrect airspeed references, but may not be considered to be valid by the pilots because of simultaneously displayed conflicting (high) airspeed and overspeed warnings			

B777 Alerting Issues – Air data system failure

2. Initiating Condition: Blocked pitot sources (all sources blocked, first partially and inconsistently, then completely), with ram air pressure trapped in at least one pitot system during climb (e.g., blocked pitot drain) – Cont.

Type	Alert or cue	Threshold for alert or cue to be presented	Confusion regarding alert or cue	Other issues with regard to alert or cue	When alert is inhibited/suppressed or when cue is masked	How alert or cue is terminated
			(due to pitot system(s) in which the ram air pressure is trapped). Resolution of the discrepancy requires effortful reference to standby airspeed display and/or to pitch/power displays; Pilots may follow incorrect airspeed guidance into an undesired aircraft state or loss of control, because the airspeed display may appear valid and the process of identifying the discrepant display(s) may require substantial time			
Visual Cues	Different airspeed values may be displayed on Captain, F/O, and Standby indicators.	In this condition the Captain's airspeed indicator displays ADIRU air data from the left pitot static system, the FO's airspeed indicator displays SAARU air data from the right pitot static system, and the standby airspeed indicator displays air data from the center pilot static system.	This is the only situation for the 777 in which these airspeed displays can differ, so pilots are not accustomed to noticing or resolving these differences. Also, just as the automated system was unable to resolve which of the three air data channels were accurate using "best two out of three," the pilots will have the same problem.			

B777 Alerting Issues – Air data system failure

2. Initiating Condition: Blocked pitot sources (all sources blocked, first partially and inconsistently, then completely), with ram air pressure trapped in at least one pitot system during climb (e.g., blocked pitot drain) – Cont.

Type	Alert or cue	Threshold for alert or cue to be presented	Confusion regarding alert or cue	Other issues with regard to alert or cue	When alert is inhibited/suppressed or when cue is masked	How alert or cue is terminated
Visual Cues	Displayed mach/airspeed may be inconsistent with displayed attitude, considering phase of flight, altitude, thrust, and weight		Resolution of the discrepancy requires effortful reference to and integration of pitch/power displays, considering multiple additional factors (weight, configuration, etc.) that must be recalled from memory or looked up			
	Displayed mach/airspeed may inconsistent with FMC ground speed/winds, IRS-displayed groundspeed, flight path vector displays		Resolution of the discrepancy requires effortful reference to multiple displays on the overhead panel and FMC, both of which may require switch selections or button pushes to display the relevant data, as well as consideration of multiple additional factors (winds aloft, true airspeed correction, etc.) that must be recalled from memory or looked up			
	Displayed mach/airspeed may be inconsistent with displayed AOA (if installed)		Resolution of the discrepancy requires effortful correlation of desired airspeed with AOA, as well as consideration of multiple additional factors (altitude, mach effects, etc.) that must be recalled from memory or looked up; at the very least the pilot must recall the guidance to maintain AOA at the gauge's 3:00 position			
Aural Cues	None					
Tactile/ Somatic Cues	Aerodynamic buffet	Actual overspeed or approach to stall	Not definitive as to cause, may suggest either high or low speed excursion			

B777 Alerting Issues – Air data system failure

2. Initiating Condition: Blocked pitot sources (all sources blocked, first partially and inconsistently, then completely), with ram air pressure trapped in at least one pitot system during climb (e.g., blocked pitot drain) – Cont.

Expected Pilot Response(s)

- When autopilot automatically disengages, revert to hand flying and maintain control. Reversion to hand flying causes workload spike and is distracting. When abnormal airspeed is recognized, immediately return the airplane to the previously memorized target pitch attitude and thrust setting for the phase of flight.
- If reacting to airspeed anomalies prior to display of NAV AIR DATA SYS on EICAS, recall that the Airspeed Unreliable procedure is relevant to this event (it is unannunciated so not automatically delivered to the EICAS queue), and perform the Airspeed Unreliable procedure.
- When NAV AIR DATA SYS is displayed on EICAS, perform the relevant procedure (this includes linkage to the Airspeed Unreliable procedure if necessary).
- Ground speed information is available from the FMC and on the instrument displays. These indications can be used as a crosscheck.
- Use the Flight Path Vector (FPV) display (selecting it if necessary on the EFIS control panel). (Note: FPV is inertial based and continues to be reliable in this event.)
- For airplanes equipped with an Angle of Attack (AOA) indicator, maintain the analog needle at approximately the three o'clock position. This approximates a safe maneuver speed or approach speed for the existing airplane configuration.
- Per the NAV AIR DATA SYS procedure, recognize that for the remainder of the flight, the autopilot, flight directors, autothrottles, flight envelope protections, PFD flap maneuvering speed indications, auto-speedbrakes, and thrust asymmetry computer are inoperative. Yaw damping is degraded, and elevator feel and rudder ratios are changed.
- RVSM altitudes no longer allowed. Hence, lower altitudes must be used which may affect fuel burn and range. Consideration for fuel stop must be considered.
- Cat II/III operations may be affected and destination choices may have to be altered.

Possible sources of confusion with regard to pilot response(s)

- It will not immediately be apparent to the pilots that (1) incorrect airspeed values are being displayed on one or more indicators, and (2) which indicators are correct and which are incorrect.
- With blocked pitot input sources and ram air trapped in the pitot system, unless source is declared invalid by the ARIDU/SAARU, the pilot conceivably may receive high speed (siren) and low speed (stick shaker) warnings simultaneously, which is extremely confusing, stressful, and distracting.
- If the aircraft is flown into an actual overspeed condition with all air data inputs missing or invalidly low, the expected overspeed warnings will be absent. The absence of an expected warning can be confusing and inhibit pilots' identification of the overspeed condition.
- If following incorrect airspeed references, the pilot may fly the airplane into an unusual attitude, which complicates interpreting the airspeed displays and maintaining control of the aircraft.
- Unreliable airspeed may cause noticeable effects in the normal speed stability of the airplane since the normal pitch control law uses indicated airspeed. (Note: If the indicated airspeed falls below 50 knots, the flight control system changes to the secondary mode.)

B777 Alerting Issues – Air data system failure

2. Initiating Condition: Blocked pitot sources (all sources blocked, first partially and inconsistently, then completely), with ram air pressure trapped in at least one pitot system during climb (e.g., blocked pitot drain) – Cont.

Issues with regard to multiple concurrent non-normal conditions

- This failure has cascading effects all the way through to the subsequent landing; e.g., the pilots must hand fly, set power manually, follow LNAV courses by visual reference to ND map (or manually tune VORs for navigation), use a non-normal landing flap setting, and manually extend speedbrakes after touchdown. These are specified in the NAV AIR DATA SYS procedure.

B777 Alerting Issues – Air data system failure

3. Initiating Condition: Air data computer failure (single module or unit; i.e., all air data outputs of ADIRU missing/invalid but SAARU is functional)

Type	Alert or cue	Threshold for alert or cue to be presented	Confusion regarding alert or cue	Other issues with regard to alert or cue	When alert is inhibited/suppressed or when cue is masked	How alert or cue is terminated
Visual Alerts	NAV AIR DATA SYS displayed on EICAS.		Alert not definitive as to underlying failure			
Aural alerts	None					
Tactile Alerts	None					
Visual Cues	None					
Aural Cues	None					
Tactile/Somatic Cues	None					

Expected Pilot Response(s)

- None required: after failure of ADIRU air data output, the SAARU automatically provides the same air data to both PFDs.